29.

The Biology of the Smoky Shrew (*Sorex fumeus fumeus* Miller)[1]

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(Plates I-IV; Text-figure 1).

The long-tailed shrews (*Sorex*) are cosmopolitan creatures, representatives of the genus occurring throughout most of North America, Europe and Asia. They reach their greatest numbers in temperate and sub-arctic lands, occupying a variety of habitats but seeming to prefer damp situations. Often these shrews are the most abundant mammalian representatives of extensive habitats, but their habits are little known. They have been religiously catalogued by the systematist, but as with most species, we know little more than their names, colors and measurements. This surprising dearth of information on such widespread and ubiquitous creatures is not surprising, for their diminutive size and retiring habits make them unworthy subjects for the attention of most naturalists. Nevertheless, these little mammals hold a peculiar fascination for some, for almost any planned study on these creatures will provide new information on their habits. The long-tailed shrews, if for no other reason than their very abundance, must play an important role in the habitat which they occupy.

The rate of growth, food habits, reproduction and behavior of *Sorex* has been little studied in North America. The best accounts, which are all too fragmentary, have been written by European students, the subject of their attentions being largely confined to the common shrew (*Sorex araneus*).

In 1927 I commenced a study of the small forest mammals of New York. Special efforts were made to secure life history data on the long-tailed shrews (*Sorex*). As time and opportunity have permitted, attention has been directed to solving the life history of the smoky shrew (*Sorex fumeus*). My repeated efforts to secure live gravid females, so that the young might be raised and described, have failed, but considerable data have been accumulated during the past ten years of study. Most of my studies have been made about Ithaca, in central western New York. The summers of 1937 and 1938 were spent on the Edmund Niles Huyck Preserve at Rensselaerville, Albany County, in eastern New York where large numbers of shrews were collected and population studies completed. Five hundred and sixteen shrews have been collected during the course of the study, and these have provided sufficient fresh material for rather complete studies on the various phases of the life of the smoky shrew.

Specimens were secured in small snap-back mouse traps baited with walnut meat, while a few shrews were captured alive in Sherman metal boxtraps.

[1] This study has been aided by a grant from the Elizabeth Thompson Science Fund of Harvard University which the writer gratefully acknowledges.

DESCRIPTION.

The smoky shrew is a relatively large *Sorex*, heavier and more powerfully built but with a shorter tail, than *Sorex dispar* which occupies part of its range. It is much larger than the common masked shrew, *Sorex cinereus cinereus*, which is occasionally found in the same runways.

The winter pelage differs decidely from that of the summer pelage. In winter the upperparts are deep mouse gray or slaty; the underparts are very much lighter, almost silvery. Some specimens have a bufty suffusion in the post-abdominal region. In summer pelage the upperparts are pale grizzled brown, the hair tips of the underpart being paler and gray at the base. The tail at all seasons is bicolored, straw yellow below and brown above. I have seen no albinistic specimens but old specimens occasionally have the hair tipped with white, or there may be a small patch of white fur on the thigh.

Summer specimens may be confused with *Sorex cinereus* (Townsend, 1935), but their greater size and darker color serve to distinguish them from their lesser kin.

Measurements. Three conventional measurements are made of mammals when they are caught and before they are made into scientific specimens, viz., total length (nose to end of last tail vertebrae); tail (base of tail to end of last tail vertebrae); hind foot (heel to end of longest claw). These measurements, unfortunately, vary with the collector and his methods, the condition of the specimen whether fresh, bloated, in rigor mortis, etc., and are largely a matter of personal equation. All the measurements listed below were made by myself, from freshly caught specimens taken in New York State.

Adult males. Twenty-six specimens average: total length, 116.5 mm.; tail, 41 mm.; hind foot, 13 mm.

Adult females. Twenty-two specimens average: total length, 116.3 mm.; tail, 43 mm.; hind foot, 12.6 mm.

Immature males. Seventeen specimens measure: total length, 113.5 mm.; tail, 41.4 mm.; hind foot, 12.7 mm.

Immature females. Fourteen individuals measure: total length, 113.1 mm.; tail, 41.2 mm.; hind foot, 12 mm.

Thus the measurements of 48 adults of both sexes average: total length, 116.4 mm.; tail, 41.9 mm.; hind foot, 12.8 mm. Thirty-one immature specimens average: total length, 112.8 mm.; tail, 41.3 mm.; hind foot 12.6 mm.

It is thus evident that the conventional external measurements provide little data on relative age, at least with this species. It is my belief that this is true of many small mammals. This belief is based on measurements of many hundreds of small mammals of various species in northeastern United States. Weights, external appearance (pelage, hairy tail tufts or bare tail tips, scarring of tail and feet) and above all, weight give a good index to the age of this shrew, and combined, are sufficient in themselves to give a ready clue to the approximate age of the animal. Tooth color and wear are infallible, and should always be resorted to in order to determine the age of the individual.

Weight. The smoky shrew has a variable weight, depending upon the amount of food it has recently ingested and also on its condition. Sufficient numbers, however, taken throughout the year, show a remarkable difference between the immature and mature animals, and the two may readily be separated on this factor alone.

Recently weaned shrews, about one month old, weigh 4 grams. They gain weight slowly and throughout the first 7 to 10 months of their lives weigh from 4 to 6.8 grams. Immature individuals of both sexes collected from June to November weigh from 5.5 grams to 6.8 grams, the average of 97 specimens of both sexes being 6.19 grams. There is no sexual variation in the weight of immature shrews.

During March, the shrew population (those which have been born the previous year) gain weight rapidly and continue to become heavier throughout the spring and summer until they die. Twenty-nine adult males collected from March to August average 8.94 grams, the extremes ranging from 6.4 grams to 11 grams. Twenty-four females collected during the same period average 7.44 grams, the extremes for these, with embryos removed in gravid individuals, being 6.7 grams to 10 grams. It is very unusual to take these adult shrews after August, and it will be shown later that they die of old age at this season.

Molt. It has already been shown that the summer pelage varies markedly from that of the winter, but the change by no means occurs at the same time each year, and it may occupy several months in any one region.

Jackson (1928) states that in the southern part of the range of *Sorex fumeus* the spring molt may begin as early as the middle of April, though most specimens at that time are still in full winter pelage. He records individuals showing molt from April 19 in the south to July 18 in the north. Jackson observed that the fall molt occupies the period during October and November, depending in part upon the latitude.

In New York it is usual to find these shrews in full winter pelage from late September until early May, although the majority of museum specimens are in summer pelage. This merely indicates that collectors are most active during the summer months. The progress of the molt is a rather insidious affair, sometimes well marked and again the hairs being shed generally over the entire body so that little demarcation can be seen between the gray pelage of winter and the brown hairs of summer. The earliest record of molt is seen in an April 22 specimen, which has a large patch of summer fur on the belly and chin.

Usually by mid-May the summer pelage has been obtained, although it may be long delayed. An adult male taken on May 6, 1938 has a few hairs of the winter pelage remaining irregularly over the back, the inguinal region and particularly the rump. On June 21, 1936, I collected an adult female which had attained the complete summer pelage except for a small patch of winter fur about the base of the tail.

The summer pelage is retained until late September or early October. Three immature shrews collected in the last week of September, 1935 and 1936, have a few patches of summer fur, usually about the head and base of the tail. Fifty-seven immature shrews collected from September 27 to October 9 were all in winter pelage except one, which had a few hairs of the summer pelage about the ears. Males tend to molt earlier in the spring and fall than females. Breeding is well under way and the first litter produced before the females have completely shed their winter coat. This is contrary to the findings of Green (1930) who trapped a gravid female on April 18, 1928, at Ricketts, Pennsylvania, in which the molt was beginning on the abdomen.

A smoky shrew is seldom collected which shows any sharp demarcation between the winter and summer pelage. The molt appears to commence on the belly, and extends over the shoulders and middle of the back, the old fur persisting longest about the ears and rump.

Inasmuch as shrews in any given locality exhibit all stages of molt over a rather long period, particularly during the spring, it might be assumed that the change of fur in the individual occupies several weeks. Wilcke (1938) observed that a captive *Sorex araneus* shed its long gray shaggy winter coat during the first two days of captivity, assuming the dark shiny summer coat in rapid time.

On May 6, 1938, I collected a large male at Ithaca, New York, which showed a prominent molt over the back and rump. Long winter hairs stood out irregularly from the new short brown fur of summer. During the two days this animal remained alive, all the winter fur was lost.

Habitat.

The smoky shrew is a northern species, reaching its abundance in the cool forested regions of Pennsylvania, New York and New England. In the beech-hemlock-striped maple woods with a ground cover of loose leaf mold and black friable soil, it is often found in considerable numbers, and, unlike its congener, *Sorex cinereus*, appears to be largely restricted to such a habitat. In New York it is often abundant in birch-hemlock woods, but is only poorly represented in the thin-soiled, rocky, dry, maple woods. While the shrew perhaps favors damp woods, and the vicinity of streams, it is often taken in areas far removed from water. This species seems particularly fond of the moss-covered boulders which lie along the wooded south slopes of valleys, where the sun does not penetrate far in the summer.

In the deep leaf mold of northern forests, one can often push a finger through the surface layer to find a cavernous void beneath the inch or two of soil which covers so completely the world beneath. By tearing away this superficial layer, the tortuous galleries and broad runways of many small forest mammals are exposed. It is in this retreat, made by the larger *Blarina*, red-backed mice, hairy-tailed moles, and kindred forms, that the smaller *Sorex* are often found in profusion, a highway of mammal travel scarcely visualized by the inexperienced observer. During the hot days of August, 1938, I made several records of temperature in these retreats. In the open woods and the borders, my thermometer read 89° F. Within the woods, where little direct sun penetrated, the temperature was 81° F. In the covered galleries of the small mammals, 6 to 10 inches below the level of the forest floor, the temperature read 69° F. Conversely, in the winter, when the forest floor was free of snow, the galleries of these animals, hidden below the forest litter, had a temperature ranging from 20° F. to 31° F. while the exposed forest floor had a temperature of 8° F.

The clumps of yew (*Taxus canadensis*) which grow from the deep leaf mold are favorite retreats for these small shrews and many have been captured in such places. The runways of moles, the tunnels canopied by rotting logs and the leaf-filled depressions which obscure so well the labyrinth of tunnels, all yield their *Sorex*.

The smoky shrew population is by no means evenly distributed throughout the forest. While there is no evidence of a communal or gregarious nature, they prefer certain localities to others and here they may often be found in some numbers. A typical habitat is shown in Plate I, Fig. 1.

Activity.

In general, shrews are active at all hours, trapping records to date not indicating that these animals have any particular time in which to feed or move about. The three common shrews of eastern United States, *Blarina brevicauda*, *Sorex fumeus* and *S. cinereus*, are active at all hours of the day and night. It appears possible that the presence or absence of suitable cover may limit their movements to certain periods, but my trapping records do not indicate this. By far the greater number have been taken at night, but this is accounted for by the collecting methods employed. In the course of the investigation, traps have been generally set in the afternoon and not attended until the following morning, so that no positive record has been obtained for the majority of specimens collected.

In order to determine at what hour catches were made, large numbers of traps were set at various times of the year and visited at 6-hour intervals. The results appear in Table I.

TABLE I.

Activity of *Sorex fumeus* as determined by time of catch.

	6 AM-12M.	12M-6 PM.	6 PM-12M.	12M-6 AM.
June 12-14, 1932 150 traps set 5-6:30 AM June 12	2	4	3	2
April 14-15, 1939 130 traps set 1-2:30 PM April 14	3	2	5	3
June 24-27, 1937 200 traps set 6 PM June 24	5	3	8	6
Oct. 6-7, 1938 140 traps set 3 PM Oct. 3	3	5	1	5

From the table above it can be seen that 27 shrews were taken from 6 A.M. to 6 P.M. while 33 shrews were trapped from 6 P.M. to 6 A.M. Although the number is admittedly small, it shows that these shrews are active at all hours. Inasmuch as these shrews live in the deep leaf mold and forest litter, they are not particularly susceptible to predation at any particular time. Their diminutive eyes probably hardly distinguish light from darkness.

ASSOCIATES.

The forest floor which serves these little shrews, provides a home for many other species. Within the same habitat many other small mammals are to be found, perhaps competing with these mammal sprites for nest sites and food. These associates vary in their numbers both from year to year and in the various habitats which one selects to study. The relative population of these to other small species may best be illustrated by noting all mammals taken on a trap line over a unit of time in similar habitat. The following examples will serve.

Maple-beech-hemlock woods, good leaf mold. Ithaca New York, June 28-29, 1939. Three hundred trap nights. *Sorex fumeus,* 9; *Blarina brevicauda,* 27; *Napaeozapus insignis,* 10; *Peromyscus leucopus noveboracensis,* 9. *Sorex fumeus* represents 16.4% of catch.

Beech-hemlock woods with deep leaf mold. Rensselaerville, New York. August 6-14. 1938. Seven hundred and fifty trap nights. *Sorex fumeus,* 18; *Blarina brevicauda,* 60; *Peromyscus* (principally *P. leucopus noveboracensis*), 66; *Synaptomys cooperi,* 6; *Zapus hudsonius,* 2; *Microtus pennsylvanicus,* 1. *Sorex fumeus* represents 11.8% of the catch.

Beech-hemlock woods with deep leaf mold. Ithaca, New York. Oct. 4-7, 1939. 800 trap nights. *Sorex fumeus,* 27; *Blarina brevicauda,* 24; *Peromyscus leucopus noveboracensis,* 26; *Clethrionomys gapperi,* 7; *Pitymys pinetorum scalopsoides,* 2; *Microtus pennsylvanicus,* 2; *Parascalops,* 1. *Sorex fumeus* represents 20.2% of the catch.

In the records above, it is seen that *Sorex fumeus* comprises 11.8 to 20.2% of the small mammal population in ideal shrew habitat for certain regions in New York. If these totals be averaged, it is found that, in the three areas discussed, *Sorex fumeus* comprises 18.3% of the small mammal population. In the northern part of the state, as the Adirondack region, and much of northern New England, certain species become more abundant, such as *Clethrionomys* and *Sorex cinereus,* and the *fumeus* population in these regions would comprise a smaller percentage of the catch.

Burrows and Nests.

The weak feet of these small shrews make digging a difficult procedure and as a consequence they utilize and occupy burrows made by larger mammals. Deep in the leaf mold are prominent subterranean galleries, some the diameter of a baseball, and others whose bore scarcely exceeds the diameter of a penny. In these burrows, from an inch to nearly a foot below the leaves and humus ceiling, a host of small mammals move, feed, breed and die. These burrows are made chiefly by the powerful hairy-tailed mole, the short-tailed shrews and certain small rodents, notably the red-back mice, jumping mice and lemming mice. Chipmunks often tunnel for some distance below the soil, and the loose texture of the rotting logs and stumps make progress easy beneath these decaying objects. The tiny *Sorex* utilize these burrows, and are often caught in such places. They occasionally occupy the punky moss-covered logs which lie half hidden in the trash and rotted leaf mold of the forest.

As evidence that little burrowing is done by these diminutive creatures, I placed smoky shrews in sizeable aquaria partly filled with friable loam pressed to a consistency found in the normal habitat of these animals. Little effort was made to dig, and when the animals did try to displace dirt with their fore paws, the efforts were weak and ineffective. It seems probable that they make no burrows but utilize entirely the runways of other species.

The nests are placed at various places in these tunnels, a favorite site being beneath a stump or rotten log. I have found one nest composed almost entirely of the hair of a cottontail rabbit, situated beneath a stump from which a shrew ran when the nest was exposed. Other nests which I have examined have been made of shredded leaves, usually situated from 4 to 9 inches below the surface. These nests are roughly spherical in shape and approximate a baseball in size. They are more compact and somewhat smaller than the bulkier nests of *Blarina*. One nest which I presume had been made by a smoky shrew (a specimen was trapped in a runway leading from the nest) was situated in a punky log which crumbled apart easily. The nest was placed at one end of the log near its base and communicated with several burrows leading into the soil beneath. Another was found at the bottom of a large mass of rotten logs which had been piled by a woodcutter, and allowed to disintegrate. This nest was placed directly on the ground, between two logs which formed part of the foundation of the pile.

None of the nests contained remains of food, but piles of scats were usually found within a few inches of the nest. Captive shrews are certainly sanitary creatures, often reserving a corner of the aquaria farthest removed from the nest in which to deposit their feces. All the nests which I have examined have been free of parasites.

Voice.

The long-tailed shrews utter diverse little notes, all with probably some meaning. When alarmed, or approached by a larger mouse or shrew, the smoky shrew utters a high pitched grating note, not unlike that of the smaller bats. If greatly disturbed, it will throw itself on its back, and with spread and waving legs, repeatedly utter these squeaking staccato notes. When foraging for food these little shrews utter an almost indiscernible twitter. I have twice seen these little forest mammals rooting through the leaf mold or appearing on the forest litter about rotted logs, the twitching nose and vibrissae held aloft, and this faint, almost inaudible twittering was kept up continually.

Senses.

In spite of the diminutive eye (Plate I, Fig. 2) sight appears to be of some importance. In very subdued light where captives were housed, the shrews experienced little difficulty in avoiding obstacles and actually turned from their trails to explore new objects which were placed in the pens while the animals were exercising. In the thick carpet of leaves and the dark tunnels beneath the forest litter, there is little need of good eyesight and it is probable that these organs are degenerating.

The sense of smell does not appear to be particularly well developed. Little opportunity was had to test this sense, but when odorous food was placed in the boxes of hungry shrews, the animals often appeared to experience difficulty in locating the food items. Indeed, on several occasions they came within a few inches of small pieces of liverwurst, which were shallowly buried, but did not find the food until they had hunted for some time.

Hearing is reasonably acute. Gentle squeaking will alarm the shrews, while loud and prolonged clapping of the hands will cause the shrews no disturbance. Blossom (1932) refers to the apparent immunity of *Sorex cinereus* to loud sounds. Sleep is often so sound that snapping the fingers or loud whistling fails to disturb the shrews immediately.

The tactile sense appears to be well developed, and the long facial vibrissae may well enable the shrew to intercept disturbances which the other senses fail to detect. Indeed, there is some reason to believe this, else why do these little creatures forever hold their long cartilaginous snouts in the air, the mobile tip and associated vibrissae moving so rapidly that it is all the observer can manage to follow these extraordinarily rapid motions?

Food.

The smoky shrew is admirably adapted for gleaning the forest floor. Its long snout, with stout inner cartilaginous support, enables it to push through the leaf mold and loose litter, and its strong hooked and protruding incisors act as efficient tweezers to gather the minute life which swarms in this habitat. Elsewhere (Hamilton, 1930) I have reported on the stomach contents of 31 *S. fumeus* which were taken from February to December. All of these contained insect remains, these being, in the order of their abundance, undetermined larvae, Coleoptera, Diptera and Hymenoptera. In addition, centipedes, sowbugs, earthworms, salamanders and vegetable matter were found.

I now have the analyses of 168 stomachs to report. These were taken in New York during every month, but the greater majority were secured in the spring and the fall. Specimens taken while a deep layer of snow covered the ground contained fragmentary remains of insects, principally small golden pupal cases and fragments of beetles which were presumably dormant. One contained what appeared to be the meat and skin of a beechnut. A dozen shrews secured in March while the ground was well frozen contained quantities of insect fragments, including dipterous remains and the legs of centipedes. During May the shrews feed chiefly upon insects, particularly beetles and their larvae, and eat a few spiders. One shrew had the toes and flesh of a small salamander, while another had parts of a snail, probably *Polygyra*. Still another had eaten several small feathers, possibly secured from a dead bird, for it is improbable that these delicate little mammals could successfully overcome a sleeping bird, even though it also be of diminutive size. I have seen juncos sleeping among the *Taxus* clumps when examining my shrew traps at night.

During the summer months the principal food of the shrews appears to be insects, but the stomachs of at least two taken during July contained a mass of flesh and fur. Again it seems improbable that the animal was not a victim of the shrew, but rather met its death in some other manner. None of the trap victims had been touched, however, upon the occasion when these two were taken. Snails, small earthworms and a quantity of vegetable matter have been recognized in autumn specimens but the food appears to differ little from that of the summer.

TABLE II.

Food habits of *Sorex fumeus*, determined from examination of 168 stomach analyses made throughout the year. The figure below the month indicates the number examined. Other figures denote the percentage frequency of occurence of the different food items.

Food	Jan. 4	Feb. 5	Mar. 14	Apr. 27	May 20	June 16	July 19	Aug. 8	Sept. 17	Oct. 21	Nov. 11	Dec. 6	Total 168
Insects	75	80	85.7	77.7	70	93.7	94.7	100.	88.2	52.4	81.8	66.6	80.0
Earthworms	..	..	7.1	14.4	15	6.2	10.5	12.5	...	9.5	23.3	...	10.1
Vegetable	50	20	14.1	14.4	25.0	18.7	5.3	50	...	...	18.2	50	14.9
Centipedes	25	..	21.4	18.5	5.0	18.7	15.8	...	5.9	9.5	18.2	16.6	13.1
Snails	..	20	...	11.1	10.0	...	10.5	...	17.6	23.8	9.1	...	10.1
Salamanders	..	..	...	3.7	5.0	...	5.3	...	...	...	...	...	1.8
Mammals	..	..	...	3.7	10.0	...	10.5	...	...	...	...	...	3.0
Sowbugs	..	..	...	11.1	...	6.2	21.1	...	...	...	9.1	...	5.3
Spiders	..	20	...	14.4	10.0	6.2	...	12.5	...	...	9.1	...	5.9
Birds	..	..	...	...	5.0	...	...	...	...	...	...	...	.6

Food Requirements. On several occasions I have had captive smoky shrews for variable periods and have observed their feeding activities. These shrews are not the prodigious feeders that many naturalists would have us believe; they never eat food equivalent to their own weight daily, at least in captivity. Nevertheless, Dixon (1924) has demonstrated that the little gray shrew (*Notiosorex*) will eat 75% of its own weight each day. Blossom (1932) observed that a captive female *Sorex cinereus,* weighing 3.6 grams, ate an average daily weight of 11.7 grams, that is, an average of approximately 3.3 times its own weight every twenty-four hours. Wahlstrom (1928) states that the food requirements of *Sorex vulgaris* are enormous and the ability to fast, even when the animal is in good health, is very low. On the other hand, Rorig (1905) maintained that a small amount of food was quite enough to maintain a captive *Sorex araneus* in good health. The shrew ate an average of 7 grams of mealworms, grubs and flesh, and was maintained for nearly three months. Inasmuch as an adult shrew of this species weighs about 12 grams, it may be seen that slightly more than half of its weight in food each day is sufficient to keep the animal in good health.

It may be that conditions under which captive shrews are kept determine their ability to survive on a moderate amount of food. Moreover, a varied assortment of *natural* foods appear to keep the captives more contented than a restricted diet of mealworms or cockroaches. My captive shrews had an assortment of small snails, mouse flesh, small earthworms, beetles, centipedes, sowbugs and siftings from the forest floor, including many spiders. All seemed to do well on this variable diet, and maintained themselves many days on an amount not exceeding half of their weight. Still, this quantity is an incredible amount for such a diminutive animal to consume. Much of the food is bulky and indigestible, for the chitinous remains of the prey pass with the feces in a state which frequently makes identification of the parts quite possible. The shrews eat at all hours, the only stay to their hunger being the necessity for short naps and the actual search for food, which seldom appears to entail any great labor.

Feeding Habits in Captivity. The most important sense utilized in searching for food appears to be that of touch. While hearing is rather acute, sight and smell seem to play a minor role, and the ever moving snout and long vibrissae probably are of major importance in apprising these shrews of their food. They utilize the burrows of many small forest rodents and the larger shrews, and within the confines of these tunnels the small prey has little chance to avoid capture. Moreover, the leaf mold may be riddled with their temporary tunnels and it is suspected, from the actions of captive specimens, that much of their prey is secured by the sensitive nose. Small prey, like flies, tiny isopods and centipedes, soil worms and the lesser beetles are merely bitten and swallowed. The larger food items, as earthworms, snails, salamanders or newborn mice are held down with the fore feet while pieces are bitten off. Wireworms, mealworms, the larger beetles and kindred prey are first paralyzed by being bitten in the head. Small salamanders (*Plethodon cinereus*) are held firmly to the ground and quickly destroyed by being bitten in the head or back, severing the spinal cord. The feet, head and viscera of these amphibians are first eaten, the remainder often being neglected for other food.

It appears improbable that these small shrews are capable of overcoming deer mice and the other small rodents which inhabit their domain. A small *Peromyscus,* weighing 14 grams, was liberated in a large aquarium with an adult *fumeus* weighing 10 grams. The shrew made several abortive efforts to capture the mouse, and once closed in, grasping its active prey by the flank. The mouse immediately broke this hold, and the discouraged shrew thereafter paid no heed to its intended victim.

Sorex fumeus probably obtains sufficient water from its food, for captives drink only a limited quantity, dipping the snout into the pan of water and tilting back the head like a chick. Blossom (1932) gave no water to his captive *S. cinereus* over nearly a three month period. Wahlstrom (1928) found his captive *Sorex vulgaris* never drank; indeed they seemed to fear the water, and one shrew upon falling into its drinking receptacle avoided it thereafter. On the contrary, captive specimens of *Sorex araneus* observed by Wilcke (1938) drank very freely, in fact after every meal.

Reproduction.

Male Reproductive Organs. The following description is based on the genital organs of a sexually mature male (Plate II, Fig. 3). The testes are oval and measure 4 by 8 mm. but occasionally are larger. The caput epididymis is often diffused and ill defined and usually partly embedded in a mass of yellow fatty tissue. The cauda epididymis is large, and in breeding animals the convoluted tubules may be distinctly seen with the aid of a low powered binocular microscope. If the tubules are visible through the walls of the epidydimis, they invariably contain sperm. This serves to determine whether the males are in a breeding condition. The proximal end of the vas deferens commences as a narrow tube, gradually swelling until its distal two-thirds is reached. Here a prominent constriction occurs, the distal part being enormously swollen into a pouch which gradually tapers until its junction with the urethra is reached. The distal swelling has a diameter 4 or 5 times as great as the tubal portion of the vas deferens. A similar condition prevails with *Blarina,* but is never so well marked. According to Brambell (1935) these swellings are composed of alveolar pouches which store sperm. During the spring, one can slit the distal pouches and make a smear which usually contains numerous sperm. Two large paired organs, with numerous villi, somewhat larger than the testes, and lying dorsad to the vasa deferentia and the bladder, have been designated the prostate glands by Arnbäck-Christie-Linde (1907). These nevertheless appear to be the seminal vesicles, for they appear essentially the

same as these latter structures in other small mammals. Their true homologies cannot be determined until a careful developmental study is made of these and associated structures in several insectivores. The large bean-shaped Cowper's glands, about two-thirds the size of the testes, lie at the base of the tail, and dorsally give one the impression of anal glands. The penis is a large organ for so small an animal. When retracted it is folded on itself so that the tip lies over the most proximal portion. When extended, it measures 16 to 18 mm. There is a suggestion of diffuse prepucial glands but no ducts are visible. The penis is without a baculum.

Weber (1898) implies that the testes in the Soricidae leave the pelvic cavity seasonally or voluntarily. I have never found the testes situated other than in a cremaster sac outside the pelvic cavity and lying near the dorsal tip of the pubis. Even in very young shrews, the testes may be teased into view with the forceps by grasping the sac and drawing the testes out. In immature shrews, the caput epididymis is more prominent than the testis, both in size and in the lighter color. Apparently the enlargement occurs within the sac, without change of position of the testes during their enlargement.

The increase in size of the reproductive organs at the onset of the breeding season must occur with great rapidity. Specimens secured in March have either very minute testes whose associated structures are barely visible macroscopically, or else the organs are much enlarged. From extensive field observation and dissection of more than a hundred males taken in the late winter or early spring, I should judge that the enlargement of the testes, seminal vesicles and Cowper's glands does not occupy more than 3 or 4 days.

The Female Reproductive Organs. The female reproductive organs of *Sorex araneus* have been well described by Brambell (1935). These organs in *Sorex fumeus* (Plate II, Fig. 4) do not differ markedly from the former species. Inasmuch as these organs are often of minute size, and their parts not easily determined, it seems desirable to give a brief description of them so that American investigators may recognize the different structures.

The ovaries of immature and anoestrous adults are minute, oval yellowish bodies, measuring no more than 1 mm. in length. The much larger ovaries of breeding animals appear like small mulberries, with corpora lutea and follicles projecting above the surface. The corpora lutea, numbering 2 to 5 for each ovary, often occupy the entire ovary. A prominent periovarian sac completely invests the ovary. The oviduct is well marked from the uterine cornu, its ovarian part having a much greater diameter than the uterine end. The entire oviduct is bent in the form of an S. Brambell (1935) states that the Fallopian tube passes diagonally through the uterine wall and projects slightly into the uterine lumen. When stretched taut, the uterine horns join at right angles to the elongated vagina, but when in situ they are coiled and thus occupy little space. The vagina is unique in being bent back upon itself, the distal portion lying dorsad to the proximal portion, so that the junction of the vagina with the uterine horns lies near the site of the bladder. This is an adaption for the excessive length of the vagina which, if it lay in position similar to other small mammals, would reach nearly to the kidneys. The lower part of the vagina merges into the urogenital sinus, where the urethra opens. The clitoris is not well marked.

The three pairs of teats are inguinal, their glands occupying much of the post abdominal and inguinal region in lactating individuals. The first pair of glands are by far the largest, occupying a large area in front of the thighs and extending almost to the sacral vertebrae. In immature shrews and anoestrous females they are small and inconspicuous.

The Breeding Season. The season of reproduction normally extends from early April into August.

Males. Males secured in January and February are all immature, weighing from 4.2 to 6 grams. The testes of these animals are minute and contain no sperm. In order to determine what individuals were fecund, the testes were removed, freed from all extraneous tissue and weighed. Microscopic examination of the epididymis was made to determine the presence or absence of sperm. It was soon evident that size of testes and macroscopic examinations of the epididymis were sufficient to determine fecundity. When the combined weight of the testes exceeded 75 milligrams, they invariably contained mature and abundant sperm. Those individuals which were not fecund had small testes, seldom exceeding 2 mm. and together not exceeding 10-15 milligrams. Sexually mature individuals possessed testes measuring 4 × 6 mm. to 4.5 × 8 mm. and the pair weighed from 105 to 145 milligrams.

The change in size of the testes and the increase in weight of the shrew at the commencement of the breeding season is accomplished with great rapidity. Several specimens taken in mid-March of successive years weigh only 5 or 6 grams and have minute testes. During the last week of March a number have been secured weighing 8-11 grams and containing enlarged descended testes which have numerous sperm. On the same dates a few have been collected which still retain their small obscure testes and give no indication that they will, in a few days, become fecund. I have taken no immature shrews from early April until early June. All males secured during this period have had enlarged testes, with swollen vas deferens and seminal vesicules (Plate II, Fig. 3). Adult males continue to maintain their fecundity through August, and the only adult captured in early September likewise had enlarged testes and abundant sperm.

Females. The females, like the males, are all immature during January and February, and show little sexual activity during March. Four females collected on March 29 weigh 6.7—10 grams, and all but one show no sign of breeding. This individual has a swollen uterus and indicates sexual activity, but there are no corpora lutea nor any sperm in the vagina. Nine females collected from April 12-14 are, judged by weight, mature animals but none were pregnant. Shrews taken on April 22 contain embryos measuring from 1-7 mm. Individuals taken on May 1 contain embryos but are not nursing. On May 5 I took 2 females, one of which contained five 5 mm. embryos and another which was actively nursing. The uterine horns show only faint placental scars, so parturition probably occurred prior to May 1.

Mating may follow partus as it does with numerous cricetine rodents, for a large female taken on May 16 was actively nursing and contained eight 2 mm. embryos. Two other females taken on the same date were nursing but were not gravid. In late May a number of lactating females have been examined, but none of these were pregnant. Twenty-four adult females taken during June were all in breeding condition. Of these, 4 were pregnant and the remainder were nursing individuals. Thirteen adult July females were all nursing, and 2 were pregnant. During August, adult shrews become increasingly scarce, only one of the 4 adult females which were examined during the second week of this month being in a breeding condition. No breeding occurs during September. An interesting instance of October breeding is given by Green (1930) who took a recently nursing shrew on October 11 at Ricketts, Pa. This is a most unusual circumstance and is difficult to explain, inasmuch as I have examined 68 females during this month, and all have been immature animals.*

From these data it may be seen that males become fecund earlier in the spring than the females, and individuals usually continue in a breeding condition after the females have all died or at least ceased to breed. It is thus concluded that the female controls the breeding season, a condition

* Of 32 females taken at Ithaca, N. Y., from Oct. 3-10, 1940, one was a recently lactating adult.

similar to that of *Blarina, Peromyscus* and several other small mammals which I have studied.

Duration of Pregnancy. Little data are at hand regarding the gestation length of shrews. This is, in large measure, due to the difficulty of keeping these animals in captivity a sufficient time to breed and thus observe the gestation period. *Blarina* has a probable gestation period of 21 days (Hamilton, 1929). According to Brambell (1935), the probable gestation of *Sorex araneus* is between 13 and 19 days, with a similar lactation period.

If sufficient numbers of adult females are examined prior to the inception of the breeding season, and suitable samples obtained at several day intervals, it is possible to estimate the probable length of the gestation. Prior to April 15, no pregnant shrews have been secured, although more than 20 individuals have been examined from March 15 to April 15. On the latter date, vaginal smears from one individual indicated the shrew was in oestrous. On April 22 and 23, shrews which I examined contained embryos having a crown-rump measurement from 1 to 7 mm. On April 26, 29 and 30 and on May 1, several shrews contained embryos measuring from 3 to 10 mm. The earliest records of lactating shrews occur on May 5, when 2 nursing specimens were secured. One had faint placental scars while the other had produced young very recently. Females taken on May 3, 5 and 9 were all actively lactating.

If the earliest pregnancies occur on or about April 15 (based on the 7 mm. embryos secured on April 23) and the earliest parturition date on or about May 4, this would place the gestation length at approximately 3 weeks. It appears likely that the gestation of this shrew is no longer than 3 weeks duration, and probably somewhat shorter.

Litter Size. Based on counts of embryos and placental scars in 42 females, the litter size averages 5.5 embryos per female. Absorption of the embryos occasionally occurs, particularly in the late litters so that an embryo count is not a positive criterion of the young actually produced. Nevertheless, the six mammae suggest that 5 or 6 young are the usual number born (Plate III, Fig. 5). The largest embryo count was 8, the smallest 2. Middleton (1931) has shown that the litter size of *Sorex araneus* becomes smaller in July, at the close of the breeding season. One might suppose that as the females became senile and approached death during mid- to late summer those continuing to breed would have smaller litters. Such diminution is not well marked. In April the litter size, based on embryo counts, was 5.8. During May it averaged 6.2; for June, 5.5, and for July, 4. A July 12 female contained 2 embryos. The single pregnant August female contained 6 embryos, one of which was being resorbed, while a lactating shrew taken on August 12 had 4 placental scars.

Dermal Glands.

Side Glands. All soricids possess side glands, small oval areas of agglutinized hairs on the side of the body midway between the fore and hind limbs. These glandular areas are composed of enlarged sweat glands lying in the deeper part of the corium of the skin and of large sebaceous glands above the sweat glands in the upper portion of the corium (Eadie, 1938).

Arnbäck-Christie-Linde (1907) found side glands restricted to the male in *Sorex vulgaris* and *Crossopus fodiens* but present in both sexes in *Crocidura.* Both sexes of *Sorex fumeus* possess these glands, although they are better developed in the male than in the female. The glands may not be evident in immature females, whereas in immature males the glandular areas are always marked on the flesh side of the skin.

A noticeable enlargement of the side glands occurs in the late winter,

coincident with the enlargement of the reproductive organs. The glands then become highly vascularized (Plate III, Fig. 6) and are evident as large reddish patches on the skin surface. Johnsen (1914) believes the scent glands, at least in the male, play an important part in the sex life of the animal. He has observed that in male shrews, the growth of the sweat glands and preparation of the secretory stages parallel the ripening of the testes. This condition certainly obtains for *Sorex fumeus*. Throughout the breeding season, the glands remain prominent in both sexes, although non-breeding adult females do not exhibit pronounced glands.

The function of these glands is problematical, but it seems possible they act in some manner to attract the sexes during the breeding season. Their relation to reproduction is evident, for only at this season are the glands well developed.

On June 12, 1932, I captured a female smoky shrew in a tin trap. The animal had been dead a short time. As I was standing near the trap, a shrew appeared in the runway, ran about the trap several times and appeared to be much excited. Its side glands were very evident, the hairs about these structures being laid back so that the semi-glabrous glandular area could readily be seen. No odor was visible until I knelt down and smelt closely of the burrow it had occupied, when the peculiar and characteristic smell of this shrew was quite evident.

Life Span.

It has long been apparent that the long-tailed shrews caught at periods other than the spring and summer months (late March to early September) were all immature individuals. A critical examination of these specimens suggests that the smoky shrew does not become mature until late winter and almost the entire adult shrew population dies during the late summer.

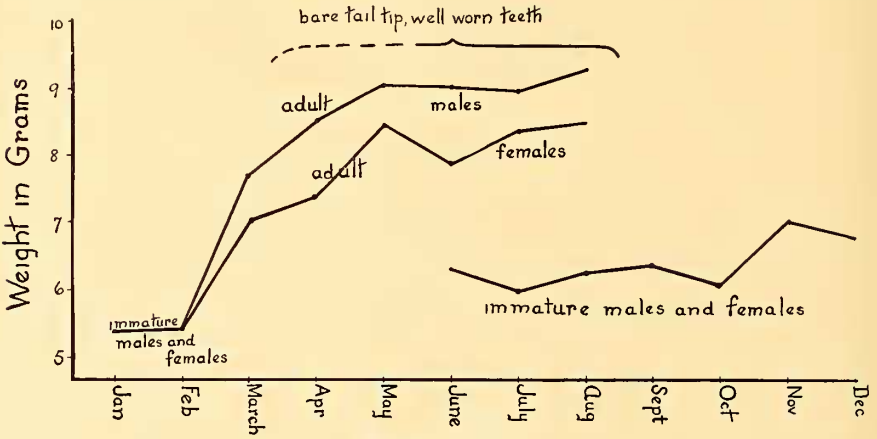
Many observers have remarked on the supposed autumnal mortality of *Sorex,* but Adams (1910) was the first to suggest the true cause. He could trap no adult males nor females after December, and concluded that the autumnal epidemic is due to nothing other than old age, this being reached in the case of *Sorex araneus* and *S. minutus* in thirteen or fourteen months. Middleton (1931), apparently unaware of Adams' study, reached a similar conclusion, viz., that all adult shrews (*Sorex araneus*), following the short but prolific breeding season, gradually die out, so that none are left by the following winter. Recently Brambell (1935), from a study of 1,064 trapped shrews (*Sorex araneus*), likewise concludes that the females live over a single winter only and die at the close of their first breeding season, the year following that in which they were born, and that the young males do not breed in the season in which they were born, and do not live over a second winter.

Montague (1922) questions the abundant testimony in support of this short life span, for a specimen of *Sorex araneus grantii* which he collected in June appeared to be undoubtedly above normal age, the teeth being almost completely worn away, while the coat is grizzled.

Certain distinguishing characters readily separate the immatures from the adults of *Sorex fumeus*. Shrews weighing 7 grams or more may be considered adult. Those with glabrous tails, the tip more or less rounded and blunt, with few or no hairs and often with numerous scars, may be considered adult. Prominent tooth wear is characteristic of adult shrews (Plate IV, Fig. 8).

Perhaps the most distinctive feature of young shrews is the general hairy condition of the tail, particularly at its tip. In young shrews, this member retains its hairy condition until April, when the shrews are eight to eleven months old (Plate III, Fig. 7).

During the year in which they are born, none of these young shrews become sexually mature. I have carefully examined the reproductive organs of more than 300 fresh immature specimens, and all indicate a quiescent stage, in which the testes are minute, seldom exceeding a millimeter in length, and the ovaries microscopically showing no indication of sexual activity. Moreover, I have collected only one adult shrew later than the first of October. It is probable that a few adult females live into the fall, for Green (1930) secured a nursing *Sorex fumeus* in northern Pennsylvania on October 11, 1927. Brambell (1935) states that immature females of *Sorex araneus* may exhibit signs of precocious sexual activity in the autumn of the season in which they are born. Even though follicular growth and vaginal cornification occur there is no evidence that these immature shrews become functionally mature. Such animals gradually pass into the typical winter condition.



Text-figure 1.

Graph demonstrating the relation of weight to age. A pronounced acceleration in weight is evident in March, when both sexes, which have overwintered as immature individuals, become sexually mature. From April to September, adults may be recognized by the increasingly worn condition of the teeth and the glabrous condition of the tail. The pencil of hairs is usually lost in May or June, but a few may be retained into August. It may be seen that the adult shrew population dies during August. A few may survive into the fall, but such is most unusual. The immature shrews lose weight in mid-winter, but their transition in March from immaturity to adults is remarkably rapid.

Examination of Text-figure 1 will show the marked disparity between the weights and tail condition of immature and adult shrews. We may thus conclude that, with *Sorex fumeus,* all of the adults, after completing their reproductive duties, die of old age when they are fourteen to seventeen months old.

Populations.

Our small native mammals are, for the most part, cyclic in nature, their populations varying from year to year. Some seasons they may exist in considerable numbers, while in other years only a few may be trapped.

During July and August, 1938, I trapped various habitats on the Huyck Preserve at Rensselaerville, Albany County, New York, to determine population levels of small mammals. In the more favorable habitats of beech and hemlock, with ground cover of *Taxus* and broad leaved herbaceous species, deep leaf mold and litter, I established several quadrats measuring

100 by 100 feet (.23 acre). Within these areas 300 traps were placed in the most promising runways, particularly in subterranean burrows and trails beneath the leaf mold. These traps were visited at dusk and dawn for a three-day period, or until the catch had been so reduced it was assumed the major part of the population had been removed. On one of these quadrats 65 small mammals were taken in three nights, 12 of which were *Sorex fumeus*. On another plot in similar habitat a quadrat yielded 68 small mammals, 10 of them being *Sorex fumeus*. In an open, sparsely wooded second growth stand of beech, maple and hemlock, with thick carpet of leaves and moss, 41 small mammals were collected on a quadrat. Six of these were smoky shrews. Thus on three quadrats of nearly a quarter acre each, there were 12, 10 and 6 smoky shrews collected, or an assumed average population of between 25 to 50 *Sorex fumeus* per acre. This was in the very best shrew habitat. One well wooded ravine, with a permanent cold stream and with black loamy slopes covering loose rock, appeared to be particularly attractive to these shrews. Yellow birch, mountain and striped maple, hemlock, witch hobble, with ground cover of liverworts, mosses and forest perennials, provided a cool retreat, and the black friable soil supported a particularly rich invertebrate fauna. In 1937 I trapped 70 *fumeus* during a three-week period in an area scarcely exceeding 1.5 acres. This intensive collecting had its effects, for a brief trapping period in 1939 indicated the population had been much reduced.

These high populations are exceptional, and are only met with in the most suitable habitats during years when shrews are numerous. In 1936 several quadrats in a beech woods near Ithaca, New York, on which I collected produced an estimated population of 9 and 14 *fumeus* per acre respectively.

While these shrews exhibit definite variable populations, and give every indication of being cyclic, I am not certain how long the cycle runs its course. About Cleveland, Ohio, Bole (1939) finds the smoky shrew very susceptible to drought, and believes they are affected by cycles as well. During the 1937-38 *Sorex* peak their numbers were estimated at 58 per acre, one of the highest ever discovered for any species by Bole. He remarks that in habitats other than climax forests this shrew is distinctly uncommon, the average being less than 1 per acre. Wherever I have found *Sorex fumeus*, the population has never been this low, although it is probable in some of the areas which I have trapped in western New York, the numbers of smoky shrews would not exceed 5-6 per acre.

The autumn population is composed almost entirely of young shrews, and as no breeding occurs from September until April, there is naturally some attrition during this season. Some years it may be rather high. Collecting was conducted on Connecticut Hill, near Ithaca, New York, in beech-hemlock woods with deep leaf mold. Traps were grouped in lots of 5-10 about stumps, beneath fallen logs, in leaf mold runways and kindred places. In 1,000 trap nights 155 mammals were collected, 17 being *Sorex fumeus*. During the first week of May, 1939, a similar trap line, in comparable habitat and under similar conditions was attended with markedly less success. Forty-six mammals were taken, of which 4 were *Sorex fumeus*. The population increased decidedly during the summer. From October 3 to 8, 1939, a thousand trap nights under situations comparable to the previous year produced 101 mammals, but of these 30 were smoky shrews. During the first week of May (May 1-5), 1940, the same number of traps produced 28 specimens and 6 of these were *fumeus*.

Thus we may conclude that, in these two years, scarcely more than 20 to 25% of the shrew population survived the winter. The winter mortality does not appear to be so great with the smaller rodents and *Blarina*, but even with these the loss may be 60% of the entire population.

Enemies.

Every small abundant mammal has a host of enemies; the smoky shrew has proved to be no exception.

The larger predators, such as the fox and bobcat, are known to capture and eat *Sorex*. Indeed the only item in the stomach of a large Vermont bobcat which I captured contained the entire body of a *Sorex cinereus*, and it is unlikely that they would shun *fumeus*. Hawks and more particularly owls, are known to prey upon them. Fresh pellets from a nesting pair of long-eared owls collected during June, 1926, near Ithaca, New York, contained the skulls of this species. Weasels capture considerable numbers of the long-tailed shrews (Dearborn, 1932; Hamilton, 1933). All of these larger predators probably make serious inroads on the shrew population but there is a more deadly and ubiquitous predator which possibly levies a fearful toll, and may be, in part, responsible for drastic reductions in the *Sorex* population. I refer to the ever-present *Blarina*, which may weigh two to four times as much as its smaller relative. Its greater size and formidable dentition are more than a match for the largest and strongest *fumeus*. On May 18, 1938, I caught a 20 gram *Blarina* whose stomach contents consisted entirely of the fur, flesh and toes of a smoky shrew. No *Sorex* had been captured in nearby traps, so it is good presumptive evidence that *Blarina* had overpowered and devoured its lesser kin. It is not without reason to suspect that this happens not infrequently in areas occupied by both species.

Parasites. The following parasites have been determined by the staff of the Bureau of Animal Industry, U. S. Department of Agriculture.

One seldom encounters a shrew without its quota of ectoparasites. Fleas are seldom found, and are never as abundant as they are on the larger *Blarina*. The only fleas which have been recovered from the smoky shrew are *Ctenophthalmus pseudagyrtes* and *Doratopsylla blarinae*, both commonly found on *Microtus*, *Peromyscus* and *Blarina*. Mites of the genus *Myobia*, *Haemogamasus* and *Protomyobia* (probably *P. clarapedi*) are often abundant, and immature individuals may exceed a hundred to a shrew. The small gamasid species burrow into the skin, particularly about the ears and vent, and these are the parasites which cause inflammation and pruritus. The anal region is often extensively scarred and pitted by the action of the mites.

Endoparasites apparently are restricted to a few nematodes. One, *Porrocaecum* sp., is found coiled in a sheath among the muscles, the external walls of the stomach and attached to the viscera generally. It is a sizeable roundworm, measuring 40 mm. or so in length, and there may be 10 or 12 when the infestation is heavy. It is thought that the adults occur in birds of prey but no experiments have been conducted to demonstrate this. Similar roundworms occur with great frequency in *Blarina*.

Summary.

A life history study of the smoky shrew, *Sorex fumeus*, in New York has been made over the past ten years to secure data on the biology of this little known species. Five hundred and sixteen shrews have been examined in the flesh and a number of captive animals have been studied, providing much new information on their biology.

It is shown that external measurements are of little value in determining age classes, but weight is of decided value, readily separating immature from mature individuals.

The smoky shrew undergoes a biannual molt. The change from the

gray winter pelage to the brown summer pelage occurs from late April until late June, and the fall molt occurs from mid-September to early October.

The smoky shrew is a northern species, attaining its greatest abundance in the cool forested regions of Pennsylvania, New York and New England. It is most numerous in the hardwood and coniferous forests which have a deep leaf mold.

This species is active at all hours. It is found in company with several other small mammals, whose runways it occupies. These associates are *Blarina brevicauda, Sorex cinereus, Peromyscus leucopus* and *P. maniculatus, Clethrionomys gapperi, Synaptomys cooperi, Napaeozapus insignis, Parascalops breweri* and several other species. In the habitats of this shrew where collecting has been most extensive, *Sorex fumeus* represents 18.3% of the small mammal population.

Little burrowing is done by the smoky shrew; it appears to occupy the runways of other small mammals, building its nests beneath stumps, rotted logs and in the galleries of *Blarina* and various rodents.

Sorex fumeus has diverse little notes, from high pitched grating, bat-like squeaks to indiscernible twitters. Sight and smell are not well developed, hearing is reasonably acute, but reliance is placed on the acute tactile sense.

On the basis of 168 stomach analyses, made from shrews taken throughout the year, it is concluded that insects are by far the most important food, being found in 80% of the stomachs. Vegetable matter was found in 14.9%; snails, 10.1%; spiders, 5.9%; sowbugs, 5.3%; mammals, 3.0%; salamanders, 1.8% and birds, .6%. Captive shrews maintain themselves well on an assortment of natural foods equal to half their weight daily. Captive individuals seldom drink.

The gross anatomy of the reproductive organs are described, attention being directed to the rapid increase in size of these organs at the onset of the breeding season. There are six teats, post-abdominal and inguinal in position. The mammary glands are very large, the first pair nearly encircling the body. The breeding season commences in late March and lasts through August, although only a small number of females breed in the latter month. Inasmuch as males become fecund earlier in the spring and remain so later in the summer than the females, it appears probable that the female controls the length of the breeding season. The duration of pregnancy is assumed to be somewhat shorter than three weeks. The litter size averages 5.5.

Dermal side glands are found in both sexes, but are more prominent in the males. They must bear some close relation to the reproductive period, for only at such a time do they enlarge and secrete the odorous material common to shrews.

The life span of the smoky shrew is short, for all the adults die of old age when they are 14 to 17 months old. This conclusion is based on the fact that no shrews breed in the year in which they are born, but pass their first winter as immature individuals. Weight, degree of hairs on the tail and tooth wear combined are infallible criteria of age, and serve readily to separate the adults from the immature shrews. Following the breeding season, the adult population of shrews die, usually in August.

The smoky shrew is probably a cyclic species, for its numbers fluctuate in different years. The shrew population varies from 5-50 individuals per acre during the late summer, but is much reduced during the winter, only 20-25% of the population surviving.

These shrews have many enemies, including predatory mammals and birds. It is pointed out that Blarina may be one of the most important

enemies. Ectoparasites include fleas (*Ctenophthalmus pseudagyrtes* and *Doratopsylla blarinae*), mites (*Myobia, Haemogamsus* and *Protomyobia*), while a nematode, *Porrocaecum*, is often abundant.

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EXPLANATION OF THE PLATES.

Plate I.

Fig. 1. Habitat of the smoky shrew. Beneath half-rotted logs and in the deep leaf mold of beech, yellow birch and hemlock woods, these small shrews are often numerous. In the area shown, twenty smoky shrews have been taken in a two-year period, in addition to scores of deer mice, red-backed mice, woodland jumping mice, short-tailed shrews and an occasional hairy-tailed mole. Ithaca, New York.

Fig. 2. Head of a freshly killed smoky shrew. The prominent ear, small eyes and long snout with prominent tactile hairs are characteristic of this species.

Plate II.

Fig. 3. Reproductive organs of an adult male *Sorex fumeus*. **A**, testes; **B**, caput epididymis; **C**, cauda epididymis; **D**, vas deferens; **E**, distal swelling of vas deferens; **F**, seminal vesicle; **G**, Cowper's gland; **H**, bladder; **I**, penis.

Fig. 4. Female reproductive tract of the smoky shrew. The uterus shows a condition about two weeks following partus. Four placental scars may distinctly be seen. **A**, suspensory ligament; **B**, ovarian capsule enclosing the ovary; **C**, proximal region of fallopian tube; **D**, uterine cornu; **E**, uterine vessels; **F**, bladder; **G**, diffuse prepucial glands; **H**, vulva.

Plate III.

Fig. 5. Mastology of nursing smoky shrew. The teats are always limited to three pairs in the position shown.

Fig. 6. Side glands viewed from the flesh side of an adult male *Sorex fumeus* collected on April 19, 1936. A strip of skin has been removed from the back and sides. The highly vascularized glandular area is prominent against the pale hide.

Fig. 7. Tails of immature and mature shrews. The upper figure is that of an immature shrew taken in October. Note the well-furred tip. The lower figure is that of an adult male collected in April. The absence of hairs on the tail tip and the eventual loss of hair over the entire tail, in addition to the scarring, is an indication of maturity.

Plate IV.

Fig. 8. Tooth wear in *Sorex fumeus*. **A**, an immature specimen collected on June 11 at a probable age of one month; **B**, immature shrew taken in November; **C**, sub-adult shrew collected in March, showing the prominent wear resulting in almost total loss of the brown tipped hooks of the first incisors; **D**, characteristic tooth row of mature shrew, as indicated in July and August specimens. The teeth of these old shrews have all lost their brown tips.